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(54) Filler metal for welding Al Zn Mg alloys

(57) Filler metals which exhibit a high resistance to stress corrosion without increasing the susceptibility of the weld to exfoliation corrosion include a copper addition which suppresses weld boundary corrosion whilst optional additions of maganese, titanium, chromium and zirconium inhibit weld cracking. The filler metal has a magnesium content of up to 5.5%, as well as a copper content of from 0.2 to 0.5% the balance being aluminium. High weld strengths are attained using this filler metal.

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SPECIFICATION

Filler metals

The present invention relates to filler metals for welding alloys of the AlZnMg type to themselves or to other aluminium alloys.

AlZnMg alloys have found wide application because of their good weldability, in particular because the weld region hardens at room temperature to the strength level of the parent metal. Initial difficulties, which were due to poor resistance to stress corrosion, were overcome by choosing the appropriate alloy composition, for example by having an appropriate Zn/Mg ratio, and by suitable heat treatment, for example multi-stage artificial ageing.

It is also known the addition of copper in amounts up to 2.0% to AlZnMg type alloys raises the strength and to a large extent prevents stress corrosion cracking from occurring.

In using these alloys in welded constructions, however, it has been found that the welds meet the requirements regarding stress corrosion, and exfoliation corrosion susceptibility, only when the construction has been heat treated as a whole, but this is often not possible, particularly for large welded constructions.

Various efforts have been made to improve the corrosion resistance of the weld by means of suitable filler metals. Thus for example in the Aluminium Taschenbuch, 13th Issue, page 551, non age-hardenable alloys of the type AlSi, AlkMg and AlMgMn have been suggested for welding AlZnMg1-alloy. The corrosion problems are indeed solved this way, but only low weld strengths can be achieved with these materials. It is clear therefore that the high strength values, which can be reached with AlZnMg alloys in welded constructions, can not be exploited with these materials.

Attempts have already been made to use AlZnMg alloys as filler metal. Thus for example in the German patent DT-OS 22 34 111 an age-hardenable aluminium filler metal of the following composition has been 1400

Zinc	2.0	to 6.0%
Magnesium	1.5	to 5.0%
Chromium	0.1	to 0.7%
Silver	0.05	to 1.04%
Bismuth	0.001	to 1.0%
Beryllium	0.001	to 1.0%
Zirconium	0.05	to 0.2%
Manganese	less than	0.4%
Silicon	less than	0.2%
Iron	less than	0.5%
Copper	less than	0.08%

The mechanical properties of the weld which can be achieved with this filler metal are comparable with those of the parent metal. This fillee metal also allowed the requirements regarding stress corrosion susceptibility to be satisfied to a large degree. It has been found however that in spite of optimal heat treatment of the welded construction, there is relatively large susceptibility to weld boundary corrosion. Therefore, although adequate strength values are obtained with such welds, there are risks involved in their use in corrosive surroundings.

The aim of the present invention has thus been to develop a filler metal which produces welds of the same strength as the parent metal at the same time as having good corrosion resistance in corrosive environments.

In a filler metal according to the present invention, for welding alloys of the AlZnMg type to themselves or to other aluminium alloys, the filler metal comprises a magnesium content of up to 5.5% as well as a copper content of from 0.2 to 0.5%. the balance being predominantly or wholly aluminium.

An example of a filler metal in accordance with the present invention has the following composition:

Zinc	1.0 to 4.0%
Magnesium	2.0 to 5.0%
Copper	0.2 to 0.5%
Manganese	0.3 to 0.5%
Titanium	0.05 to 0.2%
Titanium	0.05 to 0.02%
Chromium	0.05 to 0.3%
Zirconium	0.05 to 0.2%
Silicon	less than 0.3%
Iron	less than 0.4%
Aluminium	

rest

It was found, surprisingly, that the above example, which is based on an AlZnMg alloy, can be used for welding AlZnMg alloys without the previously mentioned disadvantages being encountered. It is assumed that above all the copper addition prevents both the occurrence of stress corrosion and weld boundary corrosion, and that the amounts of manganese, titanium, chromium and zirconium are responsible for reducing the susceptibility to weld cracking. Metallographic investigations have shown that the copper addition influences the cast structure during solidification of the weld bead, and consequently influences the boundary between the weld bead and the parent metal, in such a way that stress corrosion and in particular weld boundary corrosion are to a large extent avoided.

The tests also showed that the following particularly preferred alloying ranges influence the susceptibility to corrosion and weld cracking of the above example in a particularly favourable manner:

Zinc	2.7 to 3.3%
Magnesium	3.7 to 4.3%
Copper	0.25 to 0.35%
Manganese	0.35 to 0.45%
Titanium	0.08 to 0.15%
Chromium	0.12 to 0.20%
Zirconium	0.12 to 0.20%
Silicon	less than 0.2%
Iron	less than 0.3%
Aluminium	rest

Another example of a filler metal in accordance with the present invention, which gives weld connections to a large degree resistant to stress corrosion cracking, is obtained by adding copper in amounts of the order of 0.2 to 0.5% to the filler metals according to DIN 1732, sheet 1, in particular to filler metals of the types AlMg, AlMn and AlMgMn, the general composition of this further example being as follows:

Magnesium	up to 5.5%
Manganese	0.05 to 2.5%
Copper	0.25 to 0.5%
Chromium	0.05 to 0.3%
Zinc	0.05 to 0.25%
Titanium	0.1 to 0.25%
Silicon	less than 0.3%
Iron	less than 0.4%
Aluminium	

rest

It is regarded as surprising that the amount of copper added to filler metals in accordance with the present invention should raise the resistance of the weld to stress corrosion considerably without causing a corresponding increase in susceptibility to exfoliation corrosion in the heat affected zone in the parent metal.

Filler metals of the invention have also been found to be suitable for welding constructional parts of AlZnMg alloys to parts made out of other types of aluminium alloys such as AlMn or AlMg alloys.

The advantages of the filler metals of the invention will now be illustrated in some detail by means of the following examples.

Example 1

Samples of 4 mm thick, naturally aged sheet of a AlZnMg1-alloy were welded with the filler metals of composition given in table I using MIG-pulsed-arc welding. The welds were then tested for comparision purposes.

Table 1

Filler Metal	Zn	Mg	Cu	Ag	Mn	Ti	Cr	Zr	Si	Fe
A	1.9	4.1	0.03	–	0.45	0.10	0.12	–	0.08	0.40
B	2.2	4.0	0.05	0.95	0.48	0.11	0.11	0.12	0.10	0.41
C	2.8	4.2	0.29	–	0.44	0.10	0.18	0.17	0.21	0.38

The filler metals A and B are conventional, known filler metals; the filler metal C has a composition in accordance with the invention.

After welding the samples were artificially aged in a conventional manner.

The results of the testing are given in table II.

Table II

Filler Metal	Strength of the Weld (N/mm²)	Average Life time of "Jones" test pieces (days)
A	332	9
B	309	32
C	334	84

As table Ii showns, the filler metal prepared in accordance with the present invention exhibited a considerably improved resistance to corrosion.

Example 2

This example shows the results of testing welds in 4 mm thick sheet of an artificially aged AlZnMg1-alloys, prepared using filler metal according to DIN 1732 and a filler metal according the present invention, and by means of various welding methods. The compositions of the filler metals are given in table III.

Table III

Filler Metal	Mg	Mn	Cu	Cr	Zn	Ti	Fe	Si
S	4.9	0.35	0.05	0.12	0.12	0.17	0.38	0.30
E	4.8	0.35	0.31	0.15	0.15	0.14	0.25	0.20

Filler metal D corresponds to DIN 1732; filler metal E further contains the copper content in accordance with the present invention.

The results of testing the welds for mechanical strength and corrosion resistance are given in table IV.

Table IV

Filler Metal Welding Method	Weld Strength (N/mm²)	Average Life time of "Jones test pieces (days)
D TIG, DG (Helium)	336	24
E TIG,DC (Helium)	337	90
D MIG-Pulsed-arc	305	21
E MIG-Pulsed-arc	305	52

The corrosion resistance of the welds prepared using the filler metal composition of the invention was markedly superior to those prepared using the filler metal in accordance with DIN 1732. This was particularly so in the case of TIG,DC-Helium weld.

CLAIMS

1. A filler metal, for welding alloys of the AlZnMg type to themselves or to other aluminium alloys, the filler metal comprising a mangesium content of up to 5.5%, as well as a copper content of from 0.2 to 0.5%,

the balance being predominantly or wholly aluminium.

2. A filler metal according to claim 1, in which the magnesium content is from 2.0 to 5.0%.

3. A filler metal according to claim 2, in which the magnesium content is from 3.7 to 4.3%.

4. A filler metal according to any preceding claim, in which the copper content is from 0.25 to 0.35%.

5. A filler metal according to any preceding claim, further comprising a zirconium content of from 0.05 to 0.2%.

6. A filler metal according to claim 5, in which the zirconium content is from 0.12 to 0.2%.

7. A filler metal according to any one of claims 1 to 6, further comprising a zinc content of from 1.0 to 4.0%.

8. A filler metal according to claim 7, in which the zinc content is from 2.7 to 3.3%.

9. A filler metal according to any one of claims 1 to 6, further comprising a zinc content of from 0.05 to 0.25%.

10. A filler metal according to any preceding claim, further comprisinga manganese content of from 0.05 to 2.5%.

11. A filler metal according to claim 10, in which the manganese content is from 0.3 to 0.5%.

12. A filler metal according to claim 11, in which the manganese content is from 0.35 to 0.45%.

13. A filler metal according to any preceding claim, further comprising a titanium content of from 0.05 to 0.25%.

14. A filler metal according to claim 13, in which the titanium content is from 0.08 to 0.15%.

15. A filler metal according to any preceding claim, further comprising a chromium content of from 0.05 to 0.3%.

16. A filler metal according to claim 15, in which the chromium content is from 0.12 to 0.2%.

17. A filler metal according to any preceding claim, further comprising a zirconium content of from 0.05 to 0.2%.

18. A filler metal according to claim 17, in which the zirconium content is from 0.12 to 0.2%.

19. A filler metal according to any preceding claim, further comprising a silicon content of up to 0.3%.

20. A filler metal according to claim 19, in which the silicon content is up to 0.2%.

21. A filler metal according to any preceding claim, further comprising an iron content of up to 0.4%.

22. A filler metal according to claim 21, in which the iron content is up to 0.3%.

23. A filler metal according to claim 1 and substantially as hereinbefore described with reference to Examples C or E of the accompanying text.

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